Materializing international trade of decarbonized hydrogen by optimizing economic and environmental aspects

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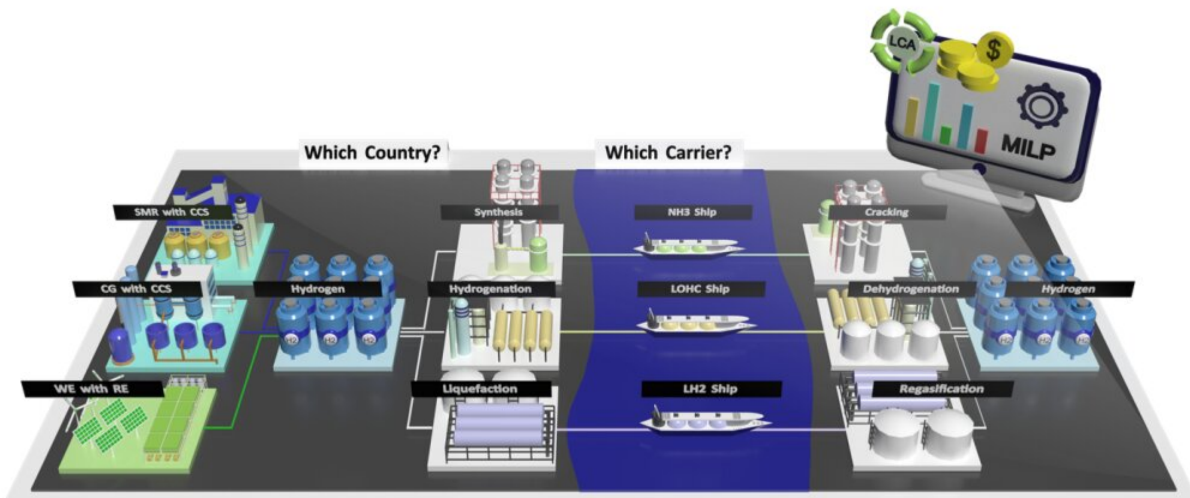


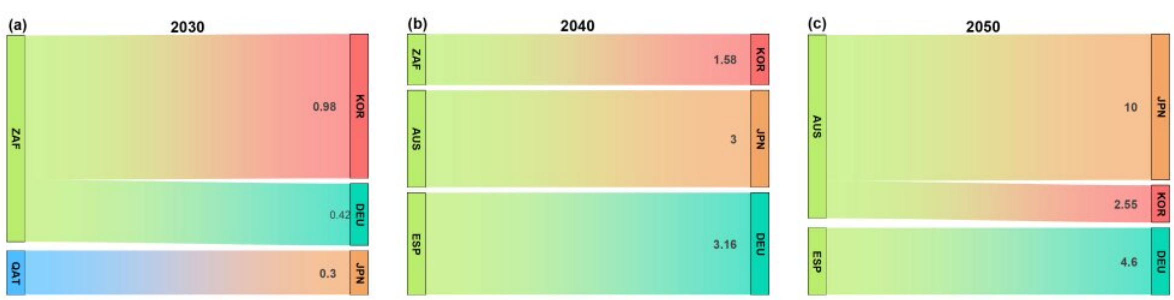
Overall schematic diagram of this study. Credit: *ACS Sustainable Chemistry & Engineering* (2022). DOI: 10.1021/acssuschemeng.2c05024

Hydrogen (H_2) has been regarded as a promising alternative energy carrier to replace fossil fuels. It is also important as a future clean energy source to achieve carbon neutrality since it does not emit carbon dioxide (CO_2). However, the cost of storing and transporting H_2 have been the major challenge for the realization of H_2 economy.

A research team, led by Professor Hankwon Lim from the Graduate School of Carbon Neutrality at UNIST has presented optimal supply chains considering economic and environmental aspects to materialize international trade of decarbonized H_2.

In this study, a comprehensive optimization for the overseas H_2 supply chain considering the three major importing countries including Korea (KOR), Japan (JPN), and Germany (DEU) was conducted with mixed-integer linear programming considering both economic and environmental aspects simultaneously. Through this optimization study, the research team verified the most feasible H_2 supply chain for each importing country according to years and case scenarios.

According to the research team, the optimization proceeded, respectively, for three case scenarios (base, conservative, and optimistic) and three years (2030, 2040, and 2050) by considering the demands of three major importers (KOR, JPN, DEU), capacities and resource prices of 16 exporters (AUS, BRA, CHL, and so on), amount of comparison of supplied H_2, and H_2 carriers (LH_2, toluene/MCH (TOL/MCH), and NH_3).



Sankey diagrams of the most optimal chains for the base case scenario, considering both economic and environmental aspects. In the case of exporters, blue H2 is indicated in blue, while green H2 is indicated in green. In the case of importers, KOR, JPN, and DEU are indicated in red, orange, and turquoise, respectively. Credit: *ACS Sustainable Chemistry & Engineering* (2022). DOI: 10.1021/acssuschemeng.2c05024

Their findings showed that in 2030, blue H_2 from QAT is the most feasible supplier for JPN, while green H_2 from ZAF is the most feasible supplier for KOR and DEU. In 2040, green H_2 from AUS also becomes one of the feasible suppliers for KOR and JPN together with ZAF and finally dominates the supplies after 2050, while green H_2 from ESP is considered to be the most feasible one for DEU after 2040.

"Although the difference between scenarios is not significant, the overall costs are different," noted the research team. "One difference is that green H_2 from AUS is selected as a more feasible supplier for KOR rather than ZAF in 2040 with the optimistic case scenario."

The study also found that ammonia (NH_3) turns out to be the most feasible carrier for H_2 and the total cost including the carbon tax has a range from 2.15 to 3.43 $ kgH_2–1 which is between the current green H_2 and blue H_2 price ranges.

The study also found that ammonia turns out to be the most feasible carrier for H_2. According to the results of the economic and environmental assessments conducted, the price of hydrogen supply, including carbon taxes generated by greenhouse gas emissions, ranged from 2.15 to $3.43 per kilogram. Based on the results, countries that are scheduled to introduce hydrogen (Korea, Japan, and Germany) have derived scenarios for optimizing the hydrogen supply chain that are needed in the future.

The work is published in the journal *ACS Sustainable Chemistry &*

Engineering.

More information: Ayeon Kim et al, Materializing International Trade of Decarbonized Hydrogen Through Optimization in Both Economic and Environmental Aspects, *ACS Sustainable Chemistry & Engineering* (2022). DOI: 10.1021/acssuschemeng.2c05024

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